The Effect of Ethnicity on Survival in Male Veterans Referred for Electrocardiography and Treadmill Testing

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Background: Ethnic differences in the relationship between access to health care and survival are difficult to define because of many confounding factors, such as socioeconomic status and baseline differences in health. Because the Veterans Affairs health care system offers health care largely without financial considerations, it provides an ideal setting in which to identify and understand ethnic differences in health outcomes. Previous studies in this area have lacked clinical and cardiovascular data with which to adjust for baseline differences in patients' health.

Methods: Data were collected from consecutive men referred for resting electrocardiography (ECG) (n=41087) or exercise testing (n=6213) during 12 years. We compared ethnic differences in survival between whites, blacks, and Hispanics after considering baseline differences in age and hospitalization status. We also adjusted for electrocardiogram abnormalities and cardiac risk factors, exercise test results, and cardiovascular comorbidities.

Results: White patients tended to be older and had more baseline comorbidities and cardiovascular interventions when they presented for testing. White patients had increased mortality rates compared with blacks and Hispanics. In the ECG population, after adjusting for demographics and baseline electrocardiogram abnormalities, Hispanics had improved survival compared with whites and blacks. In the exercise test population, after adjusting for the same factors, as well as adjusting for the presence of cardiovascular comorbidities, cardiac risk factors, and exercise test findings, Hispanics also exhibited improved survival compared with the other 2 ethnicities. There were no differences in mortality rates between whites and blacks.

Conclusion: Our findings demonstrate that the health care provided to veterans referred for routine ECG or exercise testing is not associated with poorer survival in ethnic minorities.

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ACCESS TO high quality health care for all segments of society is an important issue in the United States. Several studies[1-3] suggest that blacks and other ethnic minorities fail to receive health care that is equivalent to that received by their white counterparts. For example, some studies[4-6] have reported ethnic differences in the use of cardiac procedures. However, "use rates" alone are not indicators of quality; discrepancies in use rates may reflect differences in need, access to care, overuse in one group, or underuse in another. The important question is not whether ethnic minorities receive fewer treatments, but whether they receive health care that unfavorably affects their survival.

The Department of Veterans Affairs (VA) offers a distinct advantage for the study of ethnic differences in the delivery and outcomes of health care. Treatment within the VA system does not depend on a patient's ability to pay, and there are no financial incentives for physicians to perform procedures. Therefore, whites, blacks, Hispanics, and other ethnicities should theoretically receive equal access to health care. Also, because of the financial restrictions for eligibility for VA care, most veterans are in a similar socioeconomic class, and few can afford other sources of health care. Jha and colleagues[7] recently reported better survival in black patients compared with white patients admitted to VA hospitals. They analyzed a large administrative database and studied the outcomes of patients after admission. The authors explored several possible reasons for ethnic differences in mortality rates, including severity of illness and other comorbidities at admission, but these explanations could not be evaluated adequately because the database lacked detailed clinical information.[8]

We performed the present analysis to assess whether ethnicity affects survival in male veterans. Using our database of men referred for resting electrocardiography (ECG) or exercise testing during 12 years, we compared differences in population demographics, clinical history, cardiac risk factors, electrocardiogram abnormalities, exercise test responses, and history of cardiac procedures and their relation to long-term survival among whites, blacks, and Hispanics. Electrocardiography and exercise test results provide important findings of the extent of cardiovascular disease at baseline, and the exercise test is the best measure of baseline functional status. Given that death is most often due to cardiovascular disease among veterans within the age range studied (aged 22-93 years; mean, 55±11 years),[9] consideration of these measures as confounders is appropriate. In previous outcome studies assessing health care and ethnicity, these cardiac data have been unavailable to adjust for baseline differences in cardiovascular health.

METHODS

PATIENT SELECTION

From June 1, 1987, to July 25, 2000, 42 417 consecutive men were referred for resting ECG and another 6213 for exercise testing. On arrival for the procedure, patients were classified ethnically as white, black, Hispanic, or other (including Asian, Pacific Islander, and Native American). Classification was accomplished through patient self-categorization. Because of the ethnic heterogeneity within the "other" category, we excluded these patients from the analysis.

To evaluate our population samples for referral bias, we compared their demographics with national, state, and VA Palo Alto Health Care System ethnic data (**Table 1**).

ELECTROCARDIOGRAPHY

All patients undergoing routine ECG at the VA Palo Alto Medical Center were included in the analysis. Computerized 12-lead resting ECG findings were digitally recorded on the Marquette MAC system (GE Marquette, Milwaukee, Wis). Each electrocardiogram was labeled with the patient's social security number, and the storage file included height, weight, date of birth, ethnicity, and location of testing. Only the first ECG results were included for patients with more than 1 study in the database. The 1330 patients with no ethnic data available were excluded from analysis. The electrocardiogram abnormalities were defined according to 12 single-lead criteria of the Marquette ECG analysis program read by a board-certified cardiologist (V.F.F.).

EXERCISE TESTING

Consecutive patients referred to 2 clinical exercise laboratories (Long Beach VA Medical Center, 1987-1991; and Veterans Affairs Palo Alto Medical Center, 1992-2000) underwent a symptom-limited treadmill test.[10,11] No ethnic data were available for 47 patients, and they were excluded from analysis. The exercise laboratories were directed in a consistent fashion by 2 of us (V.F.F. and J.M.). Patients who were subjects in research protocols were not included in the analysis. Medications were not changed or stopped before testing. A thorough clinical history, list of medications, and cardiac risk factors were recorded prospectively at the time of exercise treadmill test-

Table 1. Ethnic Distribution of Veterans Affairs (VA) Medical Center Users and Patients Referred for Electrocardiography (ECG) and Exercise Testing at the VA Palo Alto Health Care System*

| Ethnicity | VA Medical Center Users | | | Our Study Patients | |
	USA (1996)	California (1996)	VA Palo Alto Health Care System (1997-2001)	ECG	Exercise Test
White	73.4	66.3	73.5	77.7	73.5
Black	22.3	21.3	12.9	12.2†	12.2
Hispanic	3.2	9.6	9.1	6.0	9.3

*Data are given as percentages. The percentages do not add up to 100 because "other" ethnicities were not considered in our analysis. Data were obtained from the VA Web site (Department of Veterans Affairs; available at: http://www.va.gov. Accessed August 2001) and local administrative databases.
†$P = .03$, χ^2 test.

ing using computerized forms.[12,13] The forms included standard definitions of clinical conditions and exercise responses.

After careful skin preparation, a standard 12-lead electrocardiogram was obtained before and continuously during exercise and for at least 5 minutes during recovery.[14] Blood pressure was taken manually, and metabolic equivalents (METs) were estimated from treadmill speed and grade. Patients did not perform a cooldown walk, but were placed supine as soon as possible after exercise.[15] No test result was classified as indeterminate.[16] The exercise tests were performed, analyzed, and documented per standard protocol using a computerized database.[17] Normal standards for age-predicted exercise capacity were derived from regression equations published previously[18]: predicted peak METs = 18.0 − 0.15(age); and age-adjusted exercise capacity = (achieved METs/predicted METs) × 100. No imaging modality was performed in conjunction with the tests. Both laboratories had affiliations with universities and had academic medical staff with rotating house officers and fellows. All tests were supervised by these individuals or by nurse practitioners; all test results were reviewed by 2 of us (V.F.F. and J.M.).

FOLLOW-UP

The Social Security Death Index was used to match all of the patients using name and social security number. The Social Security Death Index was used to ascertain vital status as of December 1999 for the ECG database and July 2000 for the exercise test database. Institutional review board approval was obtained at both institutions, and consent forms were signed by the patients undergoing exercise testing at both institutions before data collection. Institutional review board approval was obtained after ECG data collection at Veterans Affairs Palo Alto Medical Center. After using social security numbers to obtain death data, these numbers and names were removed, and an auto-number was generated to maintain patient confidentiality.

STATISTICAL METHODS

Quality control was safeguarded by data entry using specialized software at the time of testing and then by cross-entry into the VA administrative and clinical databases. These parallel data sets resulted in no more than 5% missing data in any field entered into the Cox proportional hazards regression model. Number Crunching System Software (Kaysville, Utah) was used for all statistical analyses after transferring the data from an Access (Microsoft, Redmond, Wash) database. Outliers were scru-

Table 2. Demographics and Selected Resting Electrocardiography (ECG) Abnormalities in the ECG Population*

Variable	Whites (n = 31 928)	Blacks (n = 5020)	Hispanics (n = 2454)	P Value†
Age, y	57.9 ± 14.3	51.5 ± 13.8	53.6 ± 13.7	<.001
Height, m	1.76 ± .08	1.78 ± .08	1.7 ± .07	<.001
Weight, kg	84.8 ± 17.7	85.9 ± 17.7	83.0 ± 16.6	<.001
Body mass index, kg/m²	27.3 ± 5.5	27.3 ± 5.5	28.4 ± 5.3	<.001
Inpatient	32.8	23.7	29.5	<.001
Abnormal electrocardiogram	34.2	22.8	26.0	<.001
Inferior Q waves	9.7	4.8	8.2	<.001
Left ventricular hypertrophy with strain	1.6	2.8	1.3	<.001
ST depression	18.0	11.3	11.7	<.001
Resting heart rate	74.7 ± 16.9	73.9 ± 15.9	72.5 ± 15.7	<.001
Resting systolic blood pressure	130.1 ± 19.5	130.1 ± 19.2	128.6 ± 18.8	.11

*Continuous variables are given as mean ± SD; dichotomous variables are percentages.
†Analysis of variance.

tinized and corrected when appropriate at all points of data entry and transference. Demographics and prevalence of selected ECG criteria were compared between ethnicities in the ECG population. In the exercise test population, demographics, cardiovascular comorbidities, cardiac risk factors, history of cardiac interventions, and exercise test results were compared between ethnicities. χ^2 Analysis was used to compare proportions, and analysis of variance was used to compare means between the 3 ethnic groups. $P<.05$ was considered significant.

Total (all-cause) mortality was used as the end point for survival analysis. Because the data regarding subsequent interventions were not available for all patients, patients who underwent interventions were not removed from observation. Survival analysis was displayed using Kaplan-Meier curves plotted for the ECG and exercise test populations. Log-rank tests were performed to assess if statistically significant differences in mortality rates were present between ethnicities.

Age, inpatient status, the presence of electrocardiogram abnormalities, and black and Hispanic ethnicities were included in a proportional hazards analysis to determine which variables were independent predictors of mortality. Electrocardiogram abnormalities included in the model were right ventricular hypertrophy, left bundle branch block and ST-inclusive left ventricular hypertrophy, and any other electrocardiogram abnormality (including right bundle branch block, atrial fibrillation, Q waves, premature ventricular contractions, and ST-segment depression).

In the exercise test population, age, inpatient status, presence of cardiovascular disease, cardiac risk factors (including history of hypertension, diabetes mellitus, family history of heart disease, and current smoking habit), age-adjusted exercise capacity, and black and Hispanic ethnicities were included in the proportional hazards analysis. We defined patients with cardiovascular disease as those with a history of myocardial infarction as determined through history or Q wave, coronary bypass surgery, coronary angioplasty, congestive heart failure, peripheral vascular disease, an abnormal exercise test response suggesting coronary artery disease (1.0-mm ST-segment depression, exercise-induced angina, or both), or pulmonary disease.

RESULTS

ETHNIC DEMOGRAPHICS

Comparative ethnic distributions are presented for comparison in Table 1. The ethnic distribution of patients referred for ECG and exercise testing was not statistically different, but minor statistical differences existed between those referred for ECG and the entire population of the VA Palo Alto Health Care System catchment area. The differences between VA health care users in general can be explained by local selection factors (ie, real estate value and cost of living).

PATIENT DEMOGRAPHICS

Of the 41 087 men referred for ECG with available ethnic data, 31 928 (77.7%) were white, 5020 (12.2%) were black, 2454 (6.0%) were Hispanic, and 1685 (4.1%) were of other ethnicities. The demographics and prevalence of selected resting electrocardiogram abnormalities are described in **Table 2**. White patients were older and were more likely to be inpatients. The prevalence of any electrocardiogram abnormality (Q waves, bundle branch block, atrial fibrillation, premature ventricular contractions, ST depression or left ventricular hypertrophy with strain, or right ventricular hypertrophy) was also higher among whites compared with Hispanics and blacks. Hispanics had a higher body mass index than whites or blacks. Left ventricular hypertrophy with strain was more than twice as prevalent among blacks compared with whites or Hispanics.

Among the 6166 veterans referred for exercise testing with ethnic data available, there were 4530 whites (73.5%), 754 blacks (12.2%), 576 Hispanics (9.3%), and 306 (5.0%) of other ethnicities. The population characteristics of the 3 ethnic groups are provided in **Table 3**. Blacks referred for exercise testing were younger than whites and Hispanics. Whites were more likely to have had a myocardial infarction (by history or Q wave) and congestive heart failure than blacks and Hispanics. Digoxin use was more prevalent among whites. Blacks had more hypertension and were more likely to be receiving antihypertensive medications. Whites had higher rates of cardiovascular interventions compared with blacks and Hispanics. The percentage of inpatients did not differ between the 3 ethnic groups.

Table 3 presents the cardiac risk factor profiles in the ethnic groups in the exercise test population. Blacks

Table 3. Population Characteristics in the Exercise Test Population*

Variable	Whites (n = 4530)	Blacks (n = 754)	Hispanics (n = 576)	P Value†
Demographics				
Age, y	59.7 ± 11.1	55.8 ± 11.2	57.6 ± 11.3	<.001
Height, m	1.77 ± 0.09	1.76 ± 0.08	1.73 ± 0.08	<.001
Weight, kg	87.0 ± 16.5	88.6 ± 17.5	85.5 ± 16.1	.003
Body mass index (BMI), kg/m²	27.9 ± 5.0	28.6 ± 5.2	28.4 ± 4.9	.001
Inpatient	25.2	28.9	28.0	.049
Medications				
Digoxin	5.9	3.7	4.3	.02
Calcium antagonists	26.9	29.6	26.2	.27
β-Blockers	19.6	15.8	19.3	.05
Nitrates	23.5	20.7	24.5	.18
Antihypertensive	22.1	31.2	30.6	<.001
Atrial fibrillation	3.5	2.1	0.9	<.001
Medical history				
Pulmonary disease	7.8	5.0	4.2	<.001
Stroke	3.9	2.9	3.3	.37
Claudication	5.5	4.1	6.3	.18
Typical angina	20.7	16.0	15.6	<.001
Myocardial infarction history or Q waves	31.0	19.9	28.5	<.001
Congestive heart failure	9.1	6.0	6.9	.007
Resting values				
Heart rate, beats/min	78 ± 21	79 ± 36	77 ± 15	.16
Systolic blood pressure, mm Hg	133 ± 21	136 ± 21	135 ± 25	<.001
Diastolic blood pressure, mm Hg	82 ± 17	85 ± 12	83 ± 12	<.001
History of interventions				
Percutaneous transluminal coronary angioplasty or stent	5.7	2.8	5.6	<.001
Coronary bypass surgery	9.5	2.9	5.7	<.001
Cardiac risk factors				
Diabetes	8.7	15.6	15.8	<.001
Hypercholesterolemia	28.7	33.6	31.6	.01
Family history of coronary artery disease	23.1	19.8	18.2	.006
Hypertension	44.9	60.7	53.8	<.001
Obesity (BMI>27)	28.2	34.6	30.8	.001
Smoking, %				
Currently smoking	30.2	35.9	32.3	.006
Ever smoked	55.9	59.4	55.6	.18

*Continuous variables are given as mean ± SD; dichotomous variables are percentages.
†Analysis of variance.

had a greater prevalence of risk factors, including hypertension, hypercholesterolemia, and obesity, compared with the other ethnic groups. Diabetes mellitus was significantly more prevalent among Hispanics and blacks compared with whites. A history of smoking or smoking at the time of testing was more prevalent among blacks.

EXERCISE TEST RESPONSES

No major complications were encountered during testing, although nonsustained ventricular tachycardia occurred in 81 veterans (1.3%). Exercise test results for the 3 ethnicities are presented in **Table 4**. Whites had a higher prevalence of exercise-induced angina than Hispanics or blacks, and the test was terminated more frequently in whites because of angina compared with the other ethnicities. Exercise-induced ST depression (≥1.0-mm), the most common electrocardiogram abnormality, was significantly more frequent in whites. Abnormal exercise test–induced ST-segment depression was asymptomatic two thirds of the time in all 3 ethnicities.

Blacks attained significantly higher systolic and diastolic blood pressures and mean heart rates during maximal exercise compared with the other 2 ethnic groups. Age-adjusted exercise capacity, as reflected by the percentage of maximal METs achieved, was similar between ethnicities. Patients of all ethnicities gave a good effort as reflected in the mean Borg scale rating at maximal "very hard" effort (rating, 17).
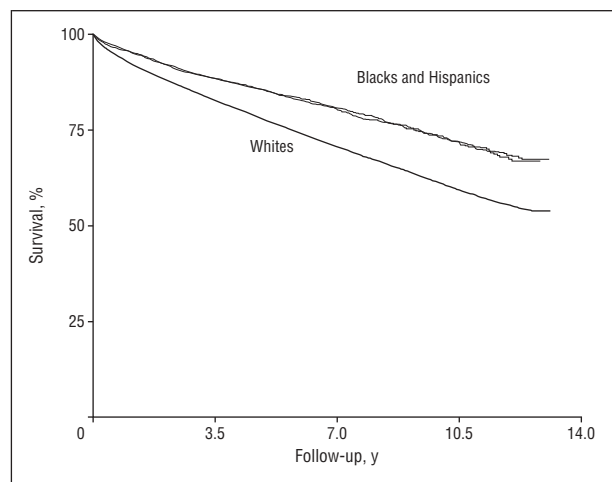
SURVIVAL

The ECG population had a mean annual mortality of 3.5% during a 12-year follow-up (mean±SD follow-up, 5.3±4.0 years), and 10 258 (25.0%) died. The mean annual all-cause mortality was 3.7% in whites, 2.6% in blacks, and 2.8% in Hispanics. The Kaplan-Meier survival plot demonstrated that whites had significantly decreased survival compared with the other 2 ethnicities (P<.01) (**Figure**). The assumption of proportional hazards was assessed by plotting the Schoenfeld residuals for each noncensored individual.[19] Because no trends were noted, the model was

Table 4. Exercise Test Responses in the Exercise Test Population*

Variable	Whites (n = 4530)	Blacks (n = 754)	Hispanics (n = 576)	P Value†
Angina occurred	18.6	15.4	12.5	<.001
Angina reason for stopping	6.3	5.2	3.3	.01
Exercise-induced ST depression (≥1.0 mm)	26.3	19.8	20.5	<.001
Silent ischemia	16.9	13.5	14.9	.045
Rate-dependent left bundle branch block	1.3	1.2	1.1	.95
Rate-dependent right bundle branch block	4.5	2.3	3.4	.07
Frequent premature ventricular contractions or ventricular tachycardia	8.5	6.8	8.3	.29
Maximum exercise				
Heart rate, beats/min	136 ± 27	142 ± 34	135 ± 26	<.001
Systolic blood pressure, mm Hg	176 ± 30	185 ± 31	179 ± 32	<.001
Diastolic blood pressure, mm Hg	85 ± 21	90 ± 17	86 ± 17	<.001
Expected age-adjusted exercise capacity, %	88.1 ± 36.1	87.8 ± 33.5	91.0 ± 34.5	.18
Perceived Borg scale exertion rating	17.1 ± 2.7	17.1 ± 2.7	17.2 ± 2.5	.52

*Continuous variables are given as mean ± SD; dichotomous variables are percentages.
†Analysis of variance.

Survival curve demonstrating survival among the 3 ethnicities in the electrocardiography population. Whites have significantly decreased survival compared with blacks and Hispanics.

Table 5. Multivariate Predictors of Mortality in Electrocardiography Population

Variable	Hazard Ratio*	χ^2†	R^2‡	P Value
Age, y	1.06 (1.05-1.06)	5862.4	0.21	<.001
Inpatient	1.02 (1.01-1.02)	6243.0	0.22	<.001
ST-inclusive left ventricular hypertrophy	1.91 (1.72-2.13)	6196.3	0.22	<.001
Right ventricular hypertrophy	2.53 (1.88-3.39)	6271.0	0.22	<.001
Left bundle branch block	1.49 (1.29-1.73)	6296.6	0.22	<.001
Other electrocardiogram abnormality	1.46 (1.40-1.53)	6087.6	0.21	<.001
Black				.06
Hispanic	0.81 (0.74-0.90)	6313.8	0.22	<.001

*Hazard ratio (with 5%-95% confidence intervals) is the relative risk of death associated with the presence of a variable.
†χ^2 Test used for testing whether the model is useful.
‡R^2 is the relative effect of all the independent variables in the regression equation.

appropriate. After adjusting for differences in age, hospitalization status, and electrocardiogram abnormalities, Hispanics had a decreased risk of mortality compared with the other ethnicities (**Table 5**).

The mean annual mortality in the population referred for exercise testing was 3.2% during the follow-up (mean±SD follow-up, 6.2±3.7 years). This mortality rate was similar to that for the population referred only for resting ECG (3.5% per year). Those who died were significantly older and had a lower mean body mass index than survivors. The mean annual mortality of whites, blacks, and Hispanics was 3.4%, 2.9%, and 2.2%, respectively. The Kaplan-Meier survival plot (not shown) was similar to that in the Figure.

At the time of exercise testing, whites had more comorbid conditions and had undergone more cardiac interventions than blacks. There was a 10% mean improvement in survival per MET increase in exercise capacity in all 3 ethnicities.

After adjusting for age, the proportional hazards analysis demonstrated that Hispanics had significantly decreased mortality rates compared with the other ethnicities in the ECG (hazard ratio, 0.81) and exercise test (hazard ratio, 0.76) populations (Table 5 and **Table 6**). These tables also include the results of the Cox proportional hazards regression analysis of the other variables that were significantly and independently associated with death.

OTHER HEALTH CARE USE

Within the VA Palo Alto Medical Center, we found similar rates of major medical insurance coverage among whites (21.3%) and Hispanics (23.5%), with slightly fewer blacks having major medical coverage (18.1%, P=.001). However, few veterans use other health care providers if they are registered in VA clinics, which require no copayment for health services.

The effect of ethnicity on health care and outcomes remains a controversial issue because studies continue to produce conflicting results. Previous research suggests that black patients with coronary disease receive fewer cardiac interventions and have increased mortality rates compared with white patients.[19] Studies[20,21] have also demonstrated that blacks have a poorer prognosis following myocardial infarction compared with whites. In contradiction to these findings, Keil et al[22] reported that death from coronary disease is not increased among blacks. Despite a higher incidence of diabetes mellitus and hypertension[23,24] and a lower rate of cardiac procedure use among black patients following myocardial infarction,[24-26] investigations have found that these differences do not translate into increased mortality rates for blacks compared with whites. Further research suggests that ethnic minorities admitted to hospitals for various diagnoses have similar or improved survival compared with their white counterparts in VA[27] and non-VA hospitals.[28] Studies investigating differences in mortality rates between whites and Hispanics are also inconclusive. Pandey et al[29] and Wei et al[30] report equal or higher rates of cardiovascular mortality among Hispanics compared with whites, while others show that Hispanics have lower all-cause and cardiovascular mortality rates[31] and a lower prevalence of myocardial infarction[32] than whites.

Adding a unique dimension to the study of the effect of ethnicity on mortality, we have adjusted for baseline ECG results, clinical data, and exercise test findings. No prior study has had such data available, and it is important to adjust for these findings because cardiovascular diseases are the major cause of death in the veteran population. We found that Hispanics referred for ECG or exercise testing at the VA hospitals had improved survival compared with whites and that there were no differences in survival between blacks and whites.

Our study has several other important strengths. The VA Health Care System offers health care largely without financial considerations; therefore, patient financial status should not alter access to medical care. Moreover, financial status should not affect referral for ECG or exercise testing, theoretically eliminating referral bias of patients entering this study. The ethnic distribution of patients referred for ECG and exercise testing paralleled the ethnic demographics of patients receiving care at the VA Palo Alto Health Care System. Although we cannot rule out referral bias, the ethnic demographics of the referral populations are similar to the VA population. In addition, because most veterans are middle to low income earners,[33] any socioeconomic differences between ethnic groups are diminished within the VA.

Through the centralized VA computer system and a Windows-based relational database[12,13] in the exercise laboratory, we had detailed information on patient demographics, cardiac risk factors, comorbidities, and exercise test findings. Moreover, although quality-of-life issues were not addressed, a key component of quality of life, exercise capacity,[34] was measured at baseline, and no differences were found between ethnicities. The larger ECG group of more than 30 000 patients allowed us to compare mortality rates and strengthened our findings in the smaller exercise test group. Administrative databases generally do not have detailed clinical information[8] concerning risk factors and test findings that was available for our study.[35,36]

A possible explanation for similar or improved survival in minorities may be baseline differences in the severity of disease. Two studies[37,38] of angiographic data reported that blacks who underwent cardiac catheterization were more likely to have minimal disease than whites. Both studies included few blacks and examined selected populations. Among patients undergoing cardiac catheterization after presenting with acute chest pain, Johnson et al[6] found that blacks had less severe angiographic disease than whites.

Our findings suggesting a lower prevalence of cardiac interventions among ethnic minorities are consistent with most previous research.[6] It has been suggested that blacks have decreased access to cardiac procedures. This lack of access could not be explained by socioeconomic status, income, or insurance coverage. Other study findings support these results, including analyses performed at VA hospitals, where financial status should not affect access to care.[4,5] Leape et al[39] examined the use of cardiac procedures in ethnic minorities in 13 of 24 hospitals in New York that provide high-technology cardiac services. They found no variations in the rate of use by sex, ethnic group, or payer status among patients treated in hospitals that provide cardiac interventions. However, underuse was significantly greater in hospitals that do not provide these services, particularly among uninsured persons.

The reasons for this inequality of care are largely unknown. Minorities may be less likely to accept recommendations for cardiac procedures. For instance, blacks were less likely than whites to state that they would undergo procedures if their physician recommended them.[40,41] The Coronary Artery Surgery Study[38] also found that blacks were 10% more likely than whites to refuse recommendations for coronary artery bypass surgery. Perhaps this is explained by ethnic differences in mortality rates[42] and survival following coronary artery bypass surgery.[43,44]

Table 6. Multivariate Predictors of Mortality in Exercise Test Population

Variable	Hazard Ratio*	χ^2†	R^2‡	P Value
Age, y	1.06 (1.05-1.07)	363.6	0.096	<.001
Inpatient	1.34 (1.19-1.51)	612.1	0.15	<.001
Predicted metabolic equivalents, %	0.99 (0.99-0.99)	586.1	0.15	<.001
Cardiovascular disease	1.38 (1.20-1.59)	634.1	0.16	<.001
Smoking	1.15 (1.01-1.31)	645.4	0.16	<.001
History of hypertension	. . .	. . .	. . .	.91
Family history cardiac artery disease	. . .	. . .	. . .	.08
Diabetes mellitus	. . .	. . .	. . .	.37
Black	. . .	. . .	. . .	.75
Hispanic	0.76 (0.61-0.94)	640.8	0.16	<.001

*Hazard ratio (with 5%-95% confidence intervals) is the relative risk of death associated with the presence of a variable.
†χ^2 Test used for testing whether the model is useful.
‡R^2 is the relative effect of all the independent variables in the regression equation.

Although our study was unique in its content, setting, and follow-up, its limitations and the inferences that can be made from the data are acknowledged. We were unable to provide information on cause of death and did not have information on cardiovascular procedures during the follow-up, so we could not remove patients from observation when these occurred. The data do not include clinical or disease severity measures that would affect clinical decision making and outcomes. Some information was self-reported and subject to recall bias. We had no way to assess referral bias except to note that the ethnic percentages referred for the 2 procedures and the ethnic distribution of VA users in general were similar. The differences between our catchment area and the national and state demographics are due to the high cost of property. Last, we had limited data on the use of other health care systems by our patients.

CONCLUSIONS

Future studies must address whether other measures of patient outcomes, such as symptoms and health-related quality of life, differ between ethnic groups. Our findings demonstrate that the health care provided to veterans referred for routine ECG or exercise testing at 2 California VA medical centers is associated with similar or improved survival for blacks and Hispanics compared with whites even after adjusting for differences in baseline cardiovascular status.

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REFERENCES

1. Alexander M, Grumbach K, Selby J, et al. Hospitalization for congestive heart failure: explaining racial differences. *JAMA*. 1995;274:1037-1042.
2. Escarce JJ, Epstein KR, Colby DC, Schwartz JS. Racial differences in the elderly's use of medical procedures and diagnostic tests. *Am J Public Health*. 1993;83:948-954.
3. Ebell MH, Smith M, Kruse JA, et al. Effect of race on survival following in-hospital cardiopulmonary resuscitation. *J Fam Pract*. 1995;40:571-577.
4. Conigliaro J, Whittle J, Good CB, et al. Understanding racial variation in the use of coronary revascularization procedures. *Arch Intern Med*. 2000;160:1329-1335.
5. Whittle J, Conigliaro J, Good CB, Lofgren RP. Racial differences in the use of invasive cardiovascular procedures in the Department of Veterans Affairs medical system. *N Engl J Med*. 1993;329:621-627.
6. Johnson PA, Lee TH, Cook EF, Rouan GW, Goldman L. Effect of race on the presentation and management of patients with acute chest pain. *Ann Intern Med*. 1993;118:593-601.
7. Jha AK, Shlipak MG, Hosmer W, Frances CD, Browner WS. Racial differences in mortality among men hospitalized in the Veterans Affairs health care system. *JAMA*. 2001;285:297-303.
8. Mark D. Race and the limits of administrative data [editorial]. *JAMA*. 2001;285:337-338.
9. Morrow K, Morris CK, Froelicher VF, et al. Prediction of cardiovascular death in men undergoing noninvasive evaluation for coronary artery disease. *Ann Intern Med*. 1993;118:689-695.
10. Wolthuis R, Froelicher VF, Fischer J, Longo M, Triebwasser J. New practical treadmill protocol for clinical use. *Am J Cardiol*. 1977;39:697-700.
11. Myers J, Buchanan N, Walsh D, Kraemer M, McAuley P, Froelicher VF. A comparison of the ramp versus standard exercise protocols. *J Am Coll Cardiol*. 1991;17:1334-1342.
12. Ustin J, Umann T, Froelicher V. Data management: a better approach. *Physicians Comput*. 1994;12:30-33.
13. Froelicher V, Shiu P. Exercise test interpretation system. *Physicians Comput*. 1996;14:40-44.
14. Gamble P, McManus H, Jensen D, Froelicher V. A comparison of the standard 12-lead electrocardiogram to exercise electrode placements. *Chest*. 1984;85:616-622.
15. Lachterman B, Lehmann KG, Abrahamson D, Froelicher VF. "Recovery only" ST-segment depression and the predictive accuracy of the exercise test. *Ann Intern Med*. 1990;112:11-16.
16. Reid M, Lachs M, Feinstein A. Use of methodological standards in diagnostic test research. *JAMA*. 1995;274:645-651.
17. Shue P, Froelicher V. Extra: an expert system for exercise test reporting. *J Noninvasive Testing*. 1998;4(suppl II):21-27.
18. Hosmer DW Jr, Lemeshow S. *Applied Survival Analysis: Regression Modeling of Time to Event Data*. New York, NY: John Wiley & Sons Inc; 1999.
19. Peterson ED, Shaw LK, DeLong ER, Pryor DB, Califf RM, Mark DB. Racial variation in the use of coronary-revascularization procedures: are the differences real? do they matter? *N Engl J Med*. 1997;336:480-486.
20. Haywood LJ. Coronary heart disease mortality/morbidity and risk in blacks, I: clinical manifestations and diagnostic criteria: the experience with the Beta Blocker Heart Attack Trial. *Am Heart J*. 1984;108(pt 2):787-793.
21. Castaner A, Simmons BE, Mar M, Cooper R. Myocardial infarction among black patients: poor prognosis after hospital discharge. *Ann Intern Med*. 1988;109:33-35.
22. Keil JE, Sutherland SE, Knapp RG, Lackland DT, Gazes PC, Tyroler HA. Mortality rates and risk factors for coronary disease in blacks as compared with white men and women. *N Engl J Med*. 1993;329:73-78.
23. Tofler GH, Stone PH, Muller JE, et al. Effects of gender and race on prognosis after myocardial infarction. *J Am Coll Cardiol*. 1987;9:473-482.
24. Maynard C, Every NR, Martin JS, Weaver WD. Long-term implications of racial differences in the use of revascularization procedures. *Am Heart J*. 1997;133:656-662.
25. Udvarhelyi S, Gatsonis C, Epstein AM, Pashos CL, Newhouse JP, McNeil BJ. Acute myocardial infarction in the Medicare population. *JAMA*. 1992;268:2530-2536.
26. Maynard C, Litwin PE, Martin JS, et al. Characteristics of black patients admitted to coronary care units in metropolitan Seattle: results from the Myocardial Infarction Triage and Intervention Registry (MITI). *Am J Cardiol*. 1991;67:18-23.
27. Peterson ED, Wright SM, Dailey J, et al. Racial differences in cardiac procedure use and survival following acute myocardial infarction in the Department of Veterans Affairs. *JAMA*. 1994;271:1175-1180.
28. Howard GS, Harper DL, Rosenthal GE. Racial variation in predicted and observed in-hospital death. *JAMA*. 1996;276:1639-1644.
29. Pandey DK, Labarthe DR, Goff DC, Chan W, Nichaman MZ. Community-wide coronary heart disease mortality in Mexican Americans equals or exceeds that in non-Hispanic whites: the Corpus Christi Heart Project. *Am J Med*. 2001;110:81-87.
30. Wei M, Mitchell BD, Haffner SM, Stern MP. Effects of cigarette smoking, diabetes, high cholesterol, and hypertension on all-cause mortality and cardiovascular disease mortality in Mexican Americans: the San Antonio Heart Study. *Am J Epidemiol*. 1996;144:1058-1065.
31. Sorlie PD, Backlund E, Johnson NJ, Rogot E. Mortality by Hispanic status in the United States. *JAMA*. 1993;270:2464-2468.
32. Mitchell BD, Hazuda HP, Haffner SM, Patterson JK, Stern MP. Myocardial infarction in Mexican-Americans and non-Hispanic whites. *Circulation*. 1991;83:45-51.
33. *Survey of Medical System Users*. Washington, DC: Dept of Veterans Affairs, Assistant Secretary for Finance and Planning, Office of Planning and Management Analysis; 1990.
34. Oldridge NB. Outcome assessment in cardiac rehabilitation: health-related quality of life and economic evaluation. *J Cardiopulm Rehabil*. 1997;17:179-194.
35. Romano PS, Luft HS. Getting the most out of messy data: problems and approaches for dealing with large administrative data sets. In: Grady ML, Schwartz HA, eds. *Medical Effectiveness Research Data Methods: Summary Report*. Rockville, Md: US Dept of Health and Human Services; 1992:57-75.
36. Hsia DC, Krushat WM, Fagan AB, Tebbutt JA, Kusserow RP. Accuracy of diagnostic coding for Medicare patients under the prospective-payment system. *N Engl J Med*. 1988;318:352-355.
37. Oberman A, Cutter G. Issues in the natural history and treatment of coronary heart disease in black populations: surgical treatment. *Am Heart J*. 1984;108:688-694.
38. Maynard C, Fisher LD, Passamani ER, Pullum T. African Americans in the Coronary Artery Surgery Study (CASS): race and clinical decision-making. *Am J Public Health*. 1986;76:1446-1448.
39. Leape LL, Hilborne LH, Bell R, Kamberg C, Brook RH. Underuse of cardiac procedures: do women, ethnic minorities, and the uninsured fail to receive needed revascularization? *Ann Intern Med*. 1999;130:183-192.
40. Schecter AD, Goldschmidt-Clermont PJ, McKee G, et al. Influence of gender, race, and education on patient preferences and receipt of cardiac catheterizations among coronary care unit patients. *Am J Cardiol*. 1996;78:996-1001.
41. Whittle J, Conigliaro J, Good CB, et al. Do patient preferences contribute to interracial differences in cardiovascular procedures use? *J Gen Intern Med*. 1997;12:267-273.
42. Keil JE, Sutherland SE, Hames CG, et al. Coronary disease mortality and risk factors in black and white men: results from the combined Charleston, SC, and Evans County, Georgia, heart studies. *Arch Intern Med*. 1995;155:1521-1527.
43. Watkins L Jr, Gardner GM, Gott V, et al. Coronary heart disease and bypass surgery in black males. *Am Heart J*. 1984;108:695-699.
44. Bridges CR, Edwards FH, Peterson ED, Coombs LP. The effect of race on coronary bypass operative mortality. *J Am Coll Cardiol*. 2000;36:1870-1876.